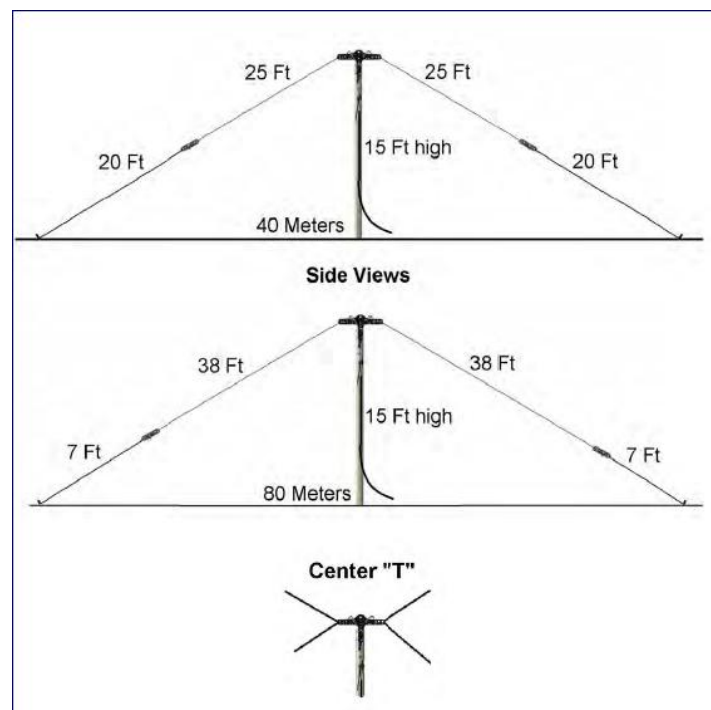
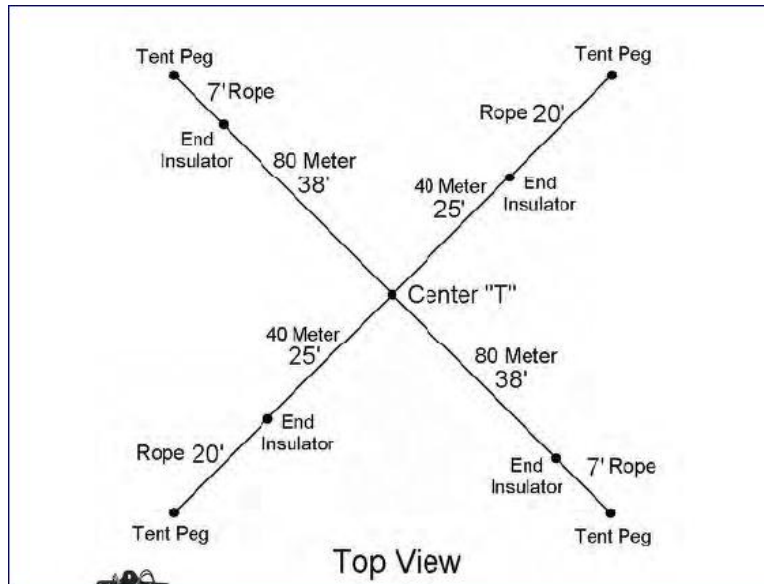


NVIS ANTENNA FIELD DAY

March 28, 2020 – Darrell Franchuk / KG4CCB

The Silver Springs Amateur Radio Club conducts an education and training session known as Ham School on the 4th Saturday of each month. However, due to the Corona Virus social distancing / gathering guidelines of the Trump Administration, the club leadership determined that the activity this month would be a home-based “field day” using a Near Vertical Incidence Skywave (NVIS) antenna. While there is a variety of information available on the Internet, the primary document I used was by DX Engineering. The DXE design is based on the military AS-2259/GR antenna used for 2MHz to 10MHz. This frequency range is due to ionospheric conditions (discussed in the DXE white paper). The overall design is illustrated below with images from the DXE whitepaper. It should be noted these sketches are not to scale. Using $a^2 + b^2 = c^2$ (Pythagorean Theorem), then $15^2 + x^2 = 45^2$, or $x^2 = 45^2 - 15^2 = 42.4\text{ft}$ (mast to radial tie-down point), approximately the 45-ft indicated in the DXE paper. This layout then requires an approximate 90-ft x 90-ft area (not 45-ft by 45-ft as indicated on page 3 of DXE paper).





The design I developed uses PVC pipe for the center support. The radial and feed line device consists of a PVC tee with eye bolts for the radials, a small piece of wood which is secured to a piece of 1-in PVC pipe with a plastic pipe clamp. The pipe clamp bolts are the electrical attachment points for the radials and the RG58X coax pigtail.



The base mount for the mast is a 4-ft piece of 2-1/2 PVC pipe secured vertically with three nylon web straps to tent stakes. The mast consists of 5-ft pieces of 2-in, 1-1/2 in, and 1-in PVC pipe which insert into one another 6-in and are stacked. The overall height is 15-ft with the center piece in place. The radials consist of No 14 insulated wire; the 40m radials are red and the 80m radials are black. Dacron paracord is used for end-of-radials tie cords to tent stakes.



There is not a large enough flat area on my property to meet the 90-ft by 90-ft footprint indicated by the DXE document. It was therefore necessary that two of the radials ran to a secure point on a slope which required the tie cords to be longer than indicated. As such, the radial angle was not as clearly indicated. This was partially addressed by visually comparing the angle of the radial tied to a point on level grade against the angle of the radial tied to a point on the slope and the slope-tied radial adjusted accordingly. In an attempt to more accurately set the radial angle, a scale sketch was developed using the measurements in the DXE document and the height of the end of radial insulator above grade was determined. The field measurements only approximated the measurements from the sketch. Considering that the NVIS variations depicted in

Internet articles and videos which achieved good results, the measurement variances were not consider significant.

The SWR of the antenna was observed with an MFJ-259B SWR Analyzer despite the DXE paper indicating they would not indicate properly. The following was observed using $SWR \leq 2.0$ as the boundary range.

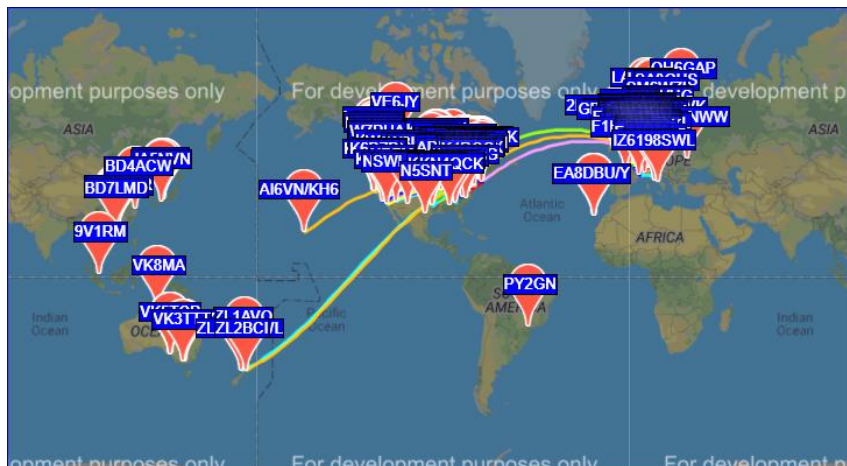
Xxx MHz / R = xx

5.308 / 51 - 5.821 / 36	8.646 / 51 – 9.328 / 54	17.990 / 28 - 18.248 / 31
27.071 / 24 – 28.462 / 50	45.680 / 39 – 47.105 / 25	63.064 / 29 – 68.119 / 61

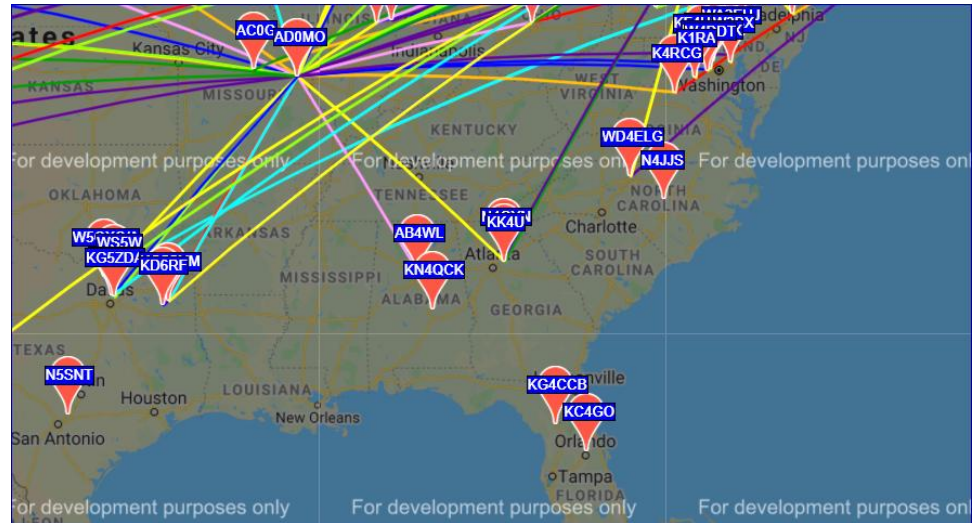
The 100-ft length of RG8X was routed into the house and connected thru an Alpha Delta antenna switch to the IC-7300. No traffic was heard on 80m. There was limited traffic on 40m and 20m. The antenna switch enabled a comparison between the NVIS antenna and the Diamond CP-5HS vertical. There was a notable difference in noise level between the two antennas; the NVIS was much quieter which resulted in voice traffic being much more readable. These comparisons were made in the early afternoon.

ANTENNA TESTING

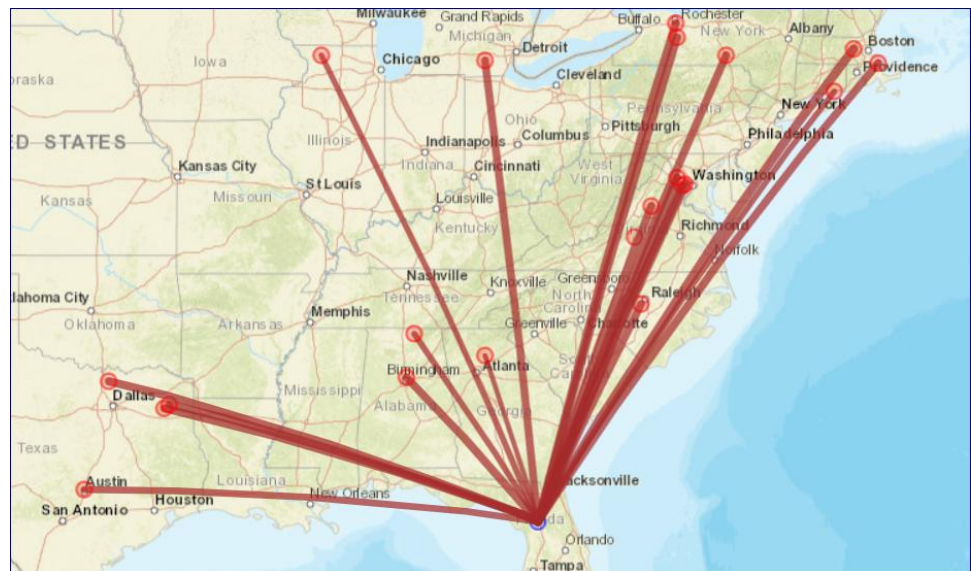
To get an idea of the antenna effectiveness, the WSPR unit was set to operate on 80m, connected to the antenna, and activated at 0748 hours. Below is a snapshot of worldwide WSPR activity on 80m. It is expected transmission receipt will be limited to an approximate 300-mile radius.



A closer look illustrates the WSPR activity in the southeast U.S. The KG4CCB transmission is shown as it is received by my own IC-7300 receiver. The transmission receipt on the IC-7300 was rather weak, which seems odd as the transmit and receive antennas are just 25-ft apart; however, the CP-5HS does not have an 80m trap radial. As illustrated, the KG4CCB transmissions were not received elsewhere.



Throughout the day, the IC-7300 monitored 80m WSPR and received no transmissions; however, the IC-7300 was inadvertently left in monitor mode and transmission receipt began at 1902 hours and ended at 0738 hours the following day. During that period 361 spots were generated, all in the eastern U.S.



In the evening, the WSPR was configured for 40m and connected to the NVIS antenna. Transmission began at 1918 hours was terminated at 0746 the following morning. During those intervening 12.5 hours 573 spots occurred that were located heavily in the eastern U.S., lightly in the

western U.S. besides Hawaii (1 location), Europe (3 locations), and Latin America (1 location). WSPR Lite transmission on 40m typically are widely received throughout the U.S. and in as many as 15 locations in Europe. Considering the reportedly “local” nature of NVIS

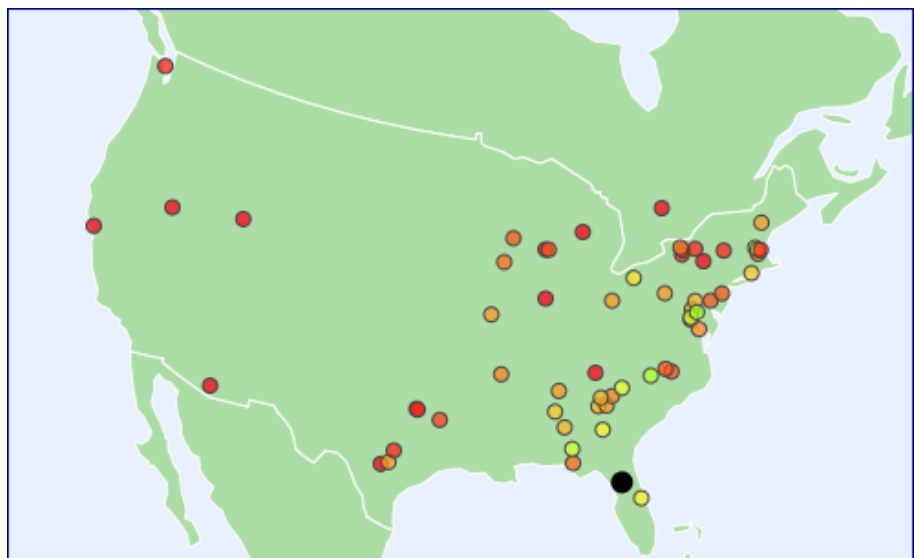
antenna
propagation,
transmission
receipt was much
wider than
anticipated.
Whether the
reduced number
of spots in the



western U.S. and Europe is the result of NVIS propagation or simply a less efficient antenna is unknown. But in all, these appears a pretty effective antenna in general.

Since the 80m signal receipt indicated night-time propagation, the WSPR Lite was configured for 80m and transmitted through the NVIS antenna overnight. When the WSPR unit was deactivated at 0610 on 3/27 there had been no transmission receipts.

At 1856 hours the WSPR unit was set to transmit on 20m into the NVIS antenna. The 40m radials had been adjusted so that the tie point was near grade, thereby providing a steeper configuration, which is



presumably a feature of NVIS propagation. Transmissions were terminated on 3/28 at

0745 hours. During the approximate 12-1/2 hours, transmissions were received predominantly in the eastern U.S., more heavily along the east coast and at four locations in the western U.S. which was slightly less than with radials at original configuration.

THE EXERCISE

On Saturday morning, 3/28, the .610 repeater was monitored awaiting Elbert to advise of 40m frequency to attempt communication. There were 4, or perhaps 5, persons participating, and communication attempts were minimally successful. Since I was unsuccessful with the NVIS antenna and one participant was successful with a random wire antenna, I tried with a connection to an EFLW antenna. It too was unsuccessful. Further the EFLW introduced a significant amount of noise and I subsequently reconnected to the NVIS antenna which is amazingly quiet. There was an abundant amount of activity on the band. Elbert also provided a 20m frequency, but the results were essentially the same.

FIELD EXERCISE FOLLOW-UP

The results were disappointing; however, the very low noise characteristic of the NVIS antenna makes it appealing for a few applications; one in particular is use for the SDR Play 1A antenna. To determine if the antenna can be practically set up for permanent use, the center feed point "T" was replaced with a Cross so it can be hung from the steel antenna mast used for my Diamond CP-5HS vertical antenna. The support point is about 14-ft above grade. The radials were spread out in a fan over a 180-deg arc to roof edge tie-points. This proved to be less effective (less received traffic and no quieter) than the Diamond vertical. Next two radials (1 each for 40m and 80m) were extended in the opposite direction to a grade level tie-point. No improvement. Next the other two radials were extended to grade level tie-points: thereby placing all four radials in a 180-deg arc. This did not improve performance. The other possible factor is the steel mast, as available documentation indicates a non-conductive mast should be used. None-the-less, the WSPR was connected and set to run on 40m for a 24-hour period with good results (this time I used a tuner, which I had overlooked earlier).



On 3/30 the WSPR was activated on 80m with the NVIS antenna through an MFJ antenna tuner and allowed to run for 14 hours. The transmissions were not received by any stations.

REFERENCE MATERIALS

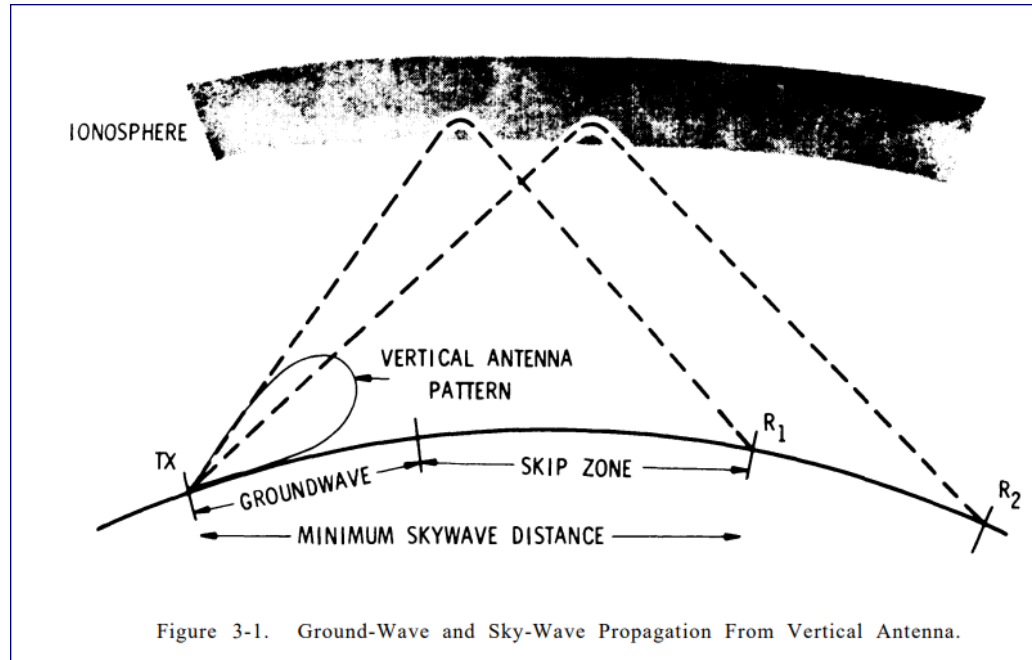
To further evaluate antenna performance and improvements needed, a limited document review was conducted. Following is a summary of key points:

Technical Manual for Antenna AS-2259/GR, HQ Department of the Army 14 February 1986.

http://www.radiomanual.info/schemi/Surplus_Accessories/AS-2259_antenna_serv_user_TM11-5985-379-14P_1986.pdf

- The antenna is designed to provide high-angle radiation (near vertical incidence) to permit short-range skywave propagation for a distance up to 300 miles.
- The frequency range is 2.0 to 30.0 MHz It may be used with a 15-whip. It may be installed on a base at grade or with a mobile mounted whip. [p 1-3]

- A limiting characteristic of whip antennas is the inherent skip zone between the end of ground wave communications (up to 70 miles) and the beginning of sky wave communications (200 miles day and 400 miles night). The skip zone is therefore, generally, between 70 and 200 / 300 miles. [p 3-1]

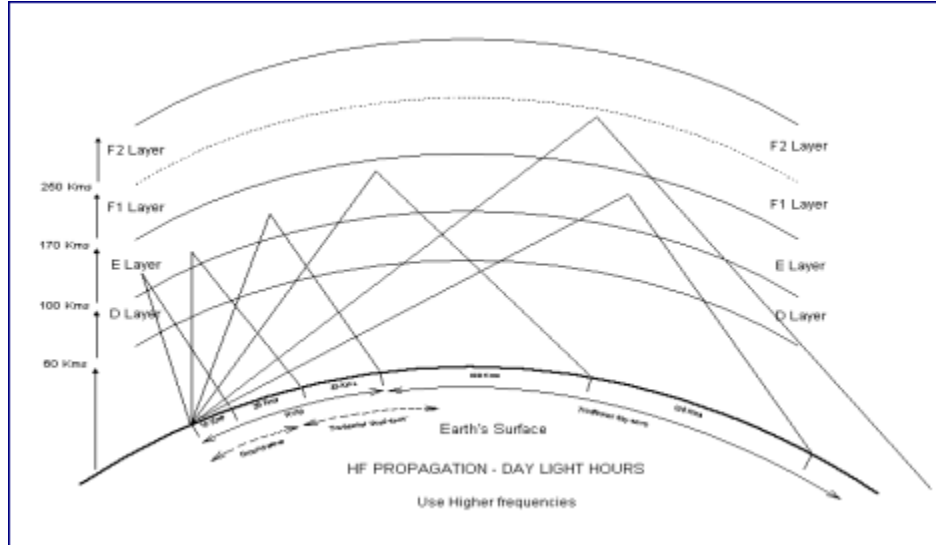


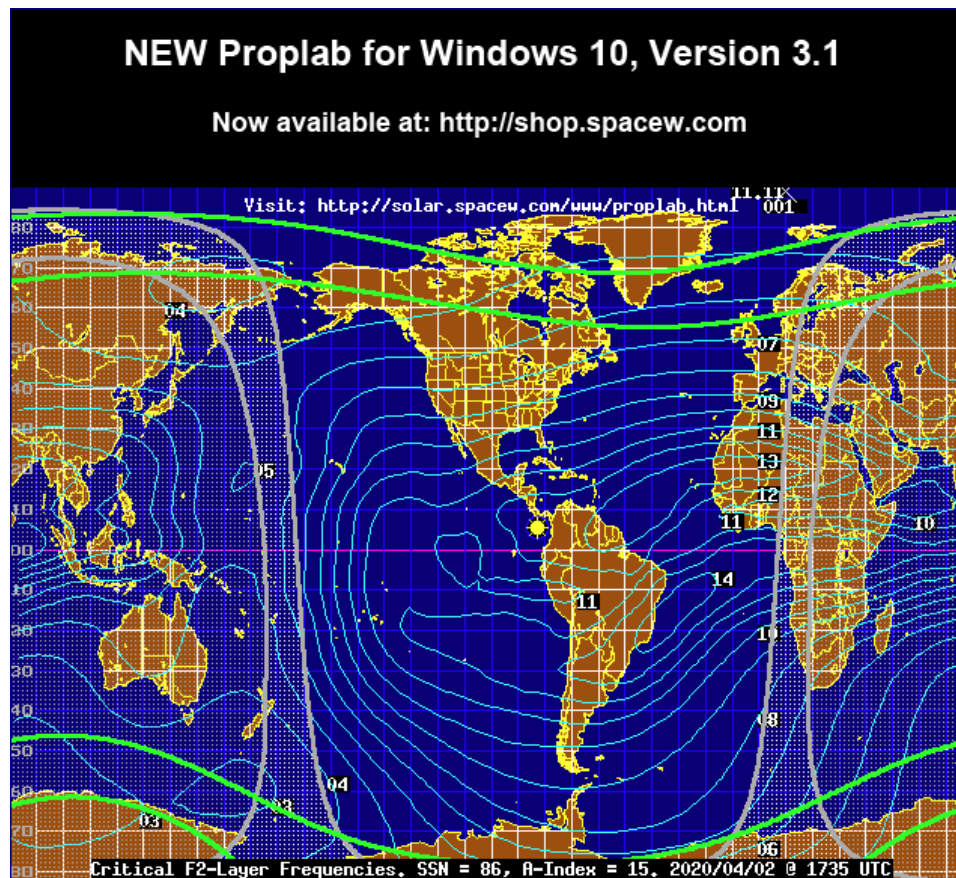
- A study of data from the Vietnam War determined that a horizontal antenna located close to the ground, i.e., less than $\frac{1}{4}$ wave, would radiate vertically. A mast height of 15-ft was selected. Design considerations included portability. [p 3-2 to 3-14]
- Radial lengths are not identified.

NVIS – Near Vertical Incident Skywave Antenna: The Emergency Communications Antenna by Stephen C. Finch, AI0W -
http://www.w8ne.com/Files/NVIS%20nvis_AI0W.pdf

- Points out the need for reliable communications with nearby stations, i.e., 10 to 400 miles away. The properly designed NVIS antenna provides for communications in the skip zone. Discusses ionospheric impact on radio waves. The steeper the angle of propagation, the smaller the coverage area. [p 1]

- Simplest antenna is resonant dipole mounted 1/8 wavelength above grade, or less. This height antenna can provide 6dbi, lowering the antenna may reduce to -1dbi. [p 2]
- Take-off angle impacts range, i.e., 87deg = 25 miles versus 68 deg = 200 miles.
- Frequency selection is dependent on ionospheric layer conditions.





- Once the critical frequency is identified, it is necessary to determine the Maximum Usable Frequency (MUF). This is determined by the angle of incidence and since NVIS is typically 90-deg, then $MUF = \text{Critical Frequency} \times 1.0$. (An angle of 72 degrees is necessary to apply a factor of 0.95) The Frequency of Optimum Traffic (FOT) = $MUF \times 0.85$. The map above indicates the Critical Frequency for Florida (at time indicated) = 9 MHz, therefore $FOT = 9 \text{ MHz} \times 0.85 = 7.65 \text{ MHz}$ [p 5-6]
- The F1 and F2 layers separate during daylight hours forming the D layer which favors 40m frequencies. During gray light times, 60m may be best. At night 80m and 160m may be better. [p 6]

Near Vertical Incidence Skywave - Wikipedia

- The most reliable frequencies are between 1.8 MHz and 8 MHz. For amateur use, 40m is generally best during day and 80m at night. During winter nights or bottom of sunspot 160m may be best.

- Military communications were commonly 2-4 MHz at night and 5-7 MHz during daytime.
- NVIS most useful in 50 to 300-mile range, or when nearby line of sight obstructed. Radio direction finding of transmitter difficult.
- Antennas consist of horizontally radiating element located from $1/20^{\text{th}}$ to $1/4$ wavelength above grade. Horizontal or Inverted-V dipoles at 0.2 wavelengths above grade good on transmit and 0.16 on receive.

HRO sells the Radio Oasis, LLC NVIS antenna for \$74.95. The HRO description is here: <https://www.hamradio.com/detail.cfm?pid=H0-014083> The Radio Oasis product website is here: <http://www.radio-oasis.com/nvis> This antenna seems to follow the DX Engineering paper as to radial lengths and mast height.

CONCLUSION

The concept is great. It is not clear why the Ham School exercise was not successful. It seems that we have a proper antenna design. I inadvertently neglected to use an antenna tuner; considering that the antennas are not resonant near 40m or 80m amateur frequencies the this likely impacted transmit effectiveness; however, the impact on receive would likely have been less significant. It seems possible that the proximity of stations involved in the exercise have been a factor, i.e., too close together for NVIS. As best I know, our antennas were properly set for vertical incidence on 40m and 80m. We should discuss further and plan a future exercise.

ADDITIONAL INFORMATION

<https://www.youtube.com/watch?v=aAshymGZ8Ww>

<https://www.youtube.com/watch?v=eyp3QXAdn6I>